Top Dilepton Cross Section Measurement
Summer 2003 -BLESSING

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on behalf of
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Outline:

- Documentation
- Q&A
- Event Selection
- Plots to Bless
- Results

Documentation

- **Q&A web page**
- http://www.cdf.fnal.gov/internal/physics/top/run2dil/summer03/doc.html
- **Related CDF Notes**
  - **CDF6517** "Adding CMIO muons to the top dilepton cross-section"
  - **CDF6579** "Optimization studies for the Top Dilepton Cross-Section Measurement"
  - **CDF6591** "Determination of Drell-Yan backgrounds for the Run II Top Dilepton Cross-Section, summer 2003"
  - **CDF6592** "Fake Lepton Backgrounds for the Summer 2003 Top Dilepton Cross Section"
  - **CDF6590** "Acceptance and Background systematics for the Top Dilepton Cross-Section Measurement"
  - **CDF6588** "A measurement of the tt cross-section using dileptons in the central and endplug detectors"
- **Previous talks at this meeting**
  - **Chris Hill,** "Dilepton Acceptance", 06/19/2003
  - **Mircea Coca**, "Dilepton Report", 07/10/2003
  - **Dave Goldstein**, "Dilepton Cross-Section", 07/17/2003
  - **Monica Tecchio,** "Preblessing", 07/24/2003
  - **Andy Hocker**, "Dilepton Cross section Update", 07/31/2003

Event Selection

- Require two leptons passing ID cuts
  - At least one of which is TIGHT
  - Plug electrons are always isolated
  - At most one central lepton (except CMIO) can be nonisolated
- If leptons are same-species with $76 < M_{ll} < 106$ GeV
  - Require “Jet Significance” > 8.0
  - $\Delta\phi$(MET, closest j) > 10°
- Corrected MET > 25 GeV
- $\Delta\phi$(closest l or j,MET) > 20° if MET < 50 GeV (“L” cut)
- Two jets with $|\eta| < 2.5$ with corrected $E_T > 15$ GeV
  - Using jet corrections levels 1,2,3,5
- Require corrected $H_T > 200$ GeV
- Require leptons to be opposite signed
  - Does not apply to PEM which do not have tracks

Q&A on Drell-Yan

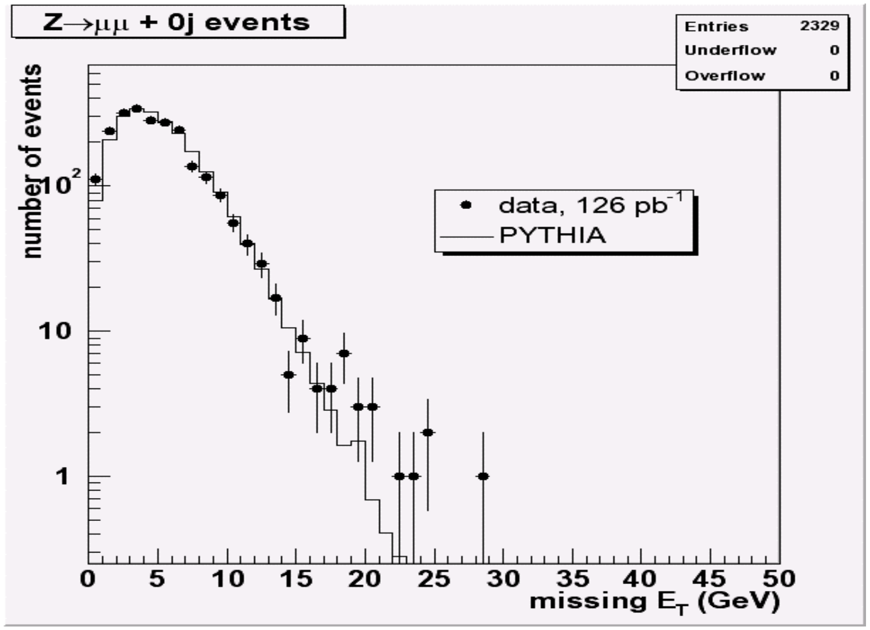
- When determining the "outside" contribution how do you account for MET cut changing the shape of the mass spectrum ?
  - Add new correction factors derived from MC

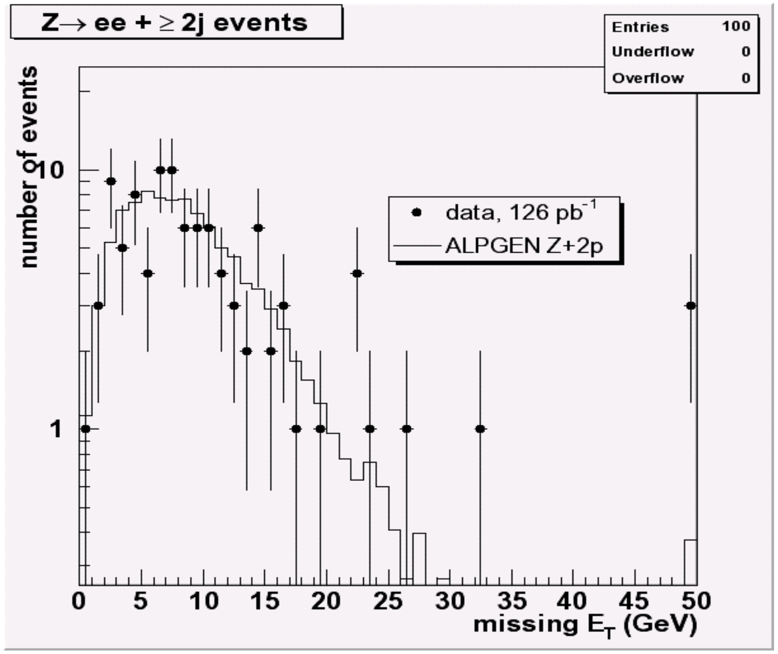
$$N_{DY}(outside) = (N_Z^p - N_{tt}^Z) \cdot \frac{e_{MET}^{lo} \cdot e_{H_T}^{lo} \cdot e_{2jet}^{lo} \cdot N_{lo} + e_{MET}^{hi} \cdot e_{H_T}^{hi} \cdot e_{2jet}^{hi} \cdot N_{hi}}{e_{MET}^{Z} \cdot e_{H_T}^{Z} \cdot e_{2jet}^{Z} \cdot N_Z}$$

Drell-Yan

- When determining cut efficiencies from the MC for the “inside” contribution how do you correct for the MC underestimating the tails of the MET distribution ?
  - Apply scale factors (Data/MC, MET > 25 GeV) to the predicted background (expected tt, WW subtracted)
  - These scale factors are determined for each jet bin and range from 0.3 to 5.8 with large uncertainties (low data statistics).
  - The average scale factor is 1.2 and a systematic is assigned such that all scale factors are consistent with this number

Drell-Yan Estimate





Channel	0j	1j	≥ 2j	H_T	OS
ee	8.2 ± 3.8	4.14 ± 1.8	1.0 ± 0.6	0.46 ± 0.29	0.46 ± 0.29
$\mu\mu$	1.2 ± 1.2	1.10 ± 1.0	0.74 ± 0.6	0.73 ± 0.56	0.73 ± 0.56
$\ell\ell$	9.4 ± 4.2	5.2 ± 2.3	1.8 ± 0.9	1.2 ± 0.7	1.2 ± 0.7

Estimate in 2 jet bin increase by 0.5 events

Drell-Yan

- Inside:
  - We try to use data as much as possible and apply correction factors due the MC poor modelling of the high-met tails
- Results:

Channel	0j	1j	≥ 2j	H_T	OS
ee	8.2 ± 3.8	4.14 ± 1.8	1.0 ± 0.6	0.46 ± 0.29	0.46 ± 0.29
$\mu\mu$	1.2 ± 1.2	1.10 ± 1.0	0.74 ± 0.6	0.73 ± 0.56	0.73 ± 0.56
$\ell\ell$	9.4 ± 4.2	5.2 ± 2.3	1.8 ± 0.9	1.2 ± 0.7	1.2 ± 0.7

Q&A on fakes

- An updated version of CDF 6592 was posted which addresses the questions
- Why does NICEM fake rate die off at higher E_T ?
  - Iso cut is a ratio, at higher $E_{T,}$ any electron looks nonisolated
- Why are fakes from CEM are larger than PEM in 2 jet bin?
  - A counting error was found and fixed
- H_T cut efficiency was derived again with a jet threshold of 20 GeV, instead of 15 GeV
  - No effect, still ~50 %
- What is the source of predicted/observed discrepancy in j20 sample ?
  - A mistake found which had to do with the fact that reclustered jets have the isolated electrons removed; now we see better agreement

More on fakes

- How to check the prediction of the fake rates in a statistically independent sample ?
  - Before we used half of j20+j50+j70 to get the fake rates and make predictions in other half of the sample; this was considered “tautological”
  - Now we use jet50 to determine the fake rates and make predictions in jet20, jet70 and jet100
  - Quote half of the largest difference (predicted – observed) as a systematic uncertainty
  - The agreement is better and systematic errors are reduced

Fake predictions-Electrons

Category	Sample	Predicted	Observed
CEM	Jet 100	3 ± 2	6
	Jet 70	18 ± 6	24
	Jet 20	10 ± 4	10
NICEM	Jet 100	12 ± 4	18
	Jet 70	59 ± 9	73
	Jet 20	8 ± 3	5
PHX	Jet 100	19 ± 6	27
	Jet 70	76 ± 13	64
	Jet 20	45 ± 10	32
PEM	Jet 100	61 ± 10	104
	Jet 70	330± 26	377
	Jet 20	278± 24	236

Fake predictions -Muons

Category	Sample	Predicted	Observed
IMUO	Jet 100	7 ± 4	4
	Jet 70	21 ± 7	11
	Jet 20	10 ± 4	17
NIMUO	Jet 100	2 ± 2	1
	Jet 70	9 ± 4	13
	Jet 20	15 ± 6	16

Systematic uncertainties

Lepton Type	Assigned Systematic Error
CEM	50%
NICEM	25%
PEM	35%
PHX	21%
IMUO	35%
NIMUO	25%

Final Fake Estimate

	0 jet	1 jet	≥ 2 jets	After H_T	After OS
CEM	0.27 ± 0.03	0.17 ± 0.02	0.13 ± 0.01	0.07 ± 0.01	0.03 ± 0.00
NICEM	1.47 ± 0.08	0.93 ± 0.05	0.59 ± 0.03	0.30 ± 0.02	0.15 ± 0.01
PEM	4.33 ± 0.15	3.13 ± 0.15	1.29 ± 0.07	0.65 ± 0.03	0.65 ± 0.03
PHX	0.99 ± 0.07	0.64 ± 0.06	0.25 ± 0.03	0.13 ± 0.01	0.06 ± 0.01
IMUO	0.28 ± 0.03	0.27 ± 0.03	0.14 ± 0.01	0.07 ± 0.01	0.04 ± 0.00
NIMUO	0.24 ± 0.03	0.20 ± 0.02	0.09 ± 0.01	0.05 ± 0.01	0.02 ± 0.00
TOTAL	7.58 ± 0.19	5.35 ± 0.17	2.50 ± 0.08	1.26 ± 0.04	0.95 ± 0.03

Tests of Fake Estimate

- Assume same-sign dilepton events come from fakes
- Compare the #SS events in different jet bins to the expected number from fakes
- PEM do not have sign information – they are excluded from the test

SS events	N = 0 jets	N =1 jets	N =2 jets
Fake Prediction SS Observed	1.6 ± 1.3 2	1.1 ± 1.0 3	0.6 ± 2
Fake Prediction (no PHX) SS Observed	1.1 ± 1.0 0	0.8 ± 0.8 0	0.5 ± 0

Acceptance Summary

- As shown before, 5% of the acceptance was coming from l+jets
- To avoid any double-counting we explicitly require in the acceptance calculation HEPG dilepton events
- Without the feed-down contribution of non-isolated categories decreases by only 1 %→ most of the non-isolated leptons are from W's

Final Acceptance

- Using Pythia ttopei the raw acceptance is:

$$(0.87 \pm 0.009)\ \%$$

- Apply the scale factors due to the MC/data id efficiencies and for trigger efficiencies → acceptance decreases by 10 %
- Acceptance has increased from Winter by almost by a factor of 2, while keeping S/B high,
  S/B = 3.2 : 1

Acceptance breakdown

CDF Run II Preliminary

Dilepton categories	Relative Acceptance (%)	S/B
CC both leptons isolated	69	4.5:1
CC one lepton non-isolated	10	4.4:1
CP/PP both leptons isolated	20	1.5:1
CP one lepton non-isolated	1	3.0:1

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Improvements breakdown

- Increase from Winter 2002 measurement:

CDF Run II Preliminary

Addition	Acceptance increase (%)
Plug electrons	30
Drop isolation 2nd lep	22
Remove the mass cut	11
Stubless muons	20

F O R B L E S S I N G

Dilepton Good Run List

- We use the final good run list specified by the top group
- L with minimal requirements = 125.8 pb^{-1}
- Require good CMX = 109 pb^{-1}
- Require good Si, no CMX req = 108 pb^{-1}
- Require good Si and CMX = 96 pb^{-1}
- We use the 12 pb^{-1} of data reprocess with correct Si alignment → no changes to the observed events

Systematic Uncertainties: Signal Acceptance

CDF Run II Preliminary

Source	Uncertainty (%)
Lepton ID SF + Trig. Effic.	2.0
Jet Corrections	5.6
ISR/FSR	1.6
PDF's	7.7
MC Generators	3.9
Total	**10.6**

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Systematic Uncertainties: Backgrounds

Background	Source	Uncertainty (%)
Z ? tt	2-jet efficiency	10
	Jet energy scale	32
WW/WZ	MC Generator	40
	Jet energy scale	17
DY (ee, mm)	Method	50
	Jet energy scale	32
Fakes	Method	21-50

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Cross Section Table

Source	Events per 125 pb^{-1} after all cuts			
	ee	$\mu\mu$	$e\mu$	$\ell\ell$
WW/WZ	0.14 ± 0.06	0.09 ± 0.04	0.17 ± 0.07	0.40 ± 0.17
Drell-Yan	0.53 ± 0.26	0.28 ± 0.14	-	0.81 ± 0.40
$Z \rightarrow \tau\tau$	0.07 ± 0.02	0.08 ± 0.03	0.17 ± 0.06	0.32 ± 0.11
Fakes	0.31 ± 0.16	0.02 ± 0.01	0.14 ± 0.07	0.53 ± 0.27
Total Background	1.05 ± 0.31	0.37 ± 0.15	0.48 ± 0.12	2.1 ± 0.5
$t\bar{t}$	1.65 ± 0.22	1.40 ± 0.19	3.50 ± 0.47	6.6 ± 0.9
Total SM expectation	2.7 ± 0.4	1.8 ± 0.2	4.0 ± 0.5	8.7 ± 1.0
Run II data	2	4	5	11

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Final Result

$$s_{tt} = 9.1 \pm 3.4(stat) \pm 1.2(syst) \pm 0.5(lum)\, pb$$

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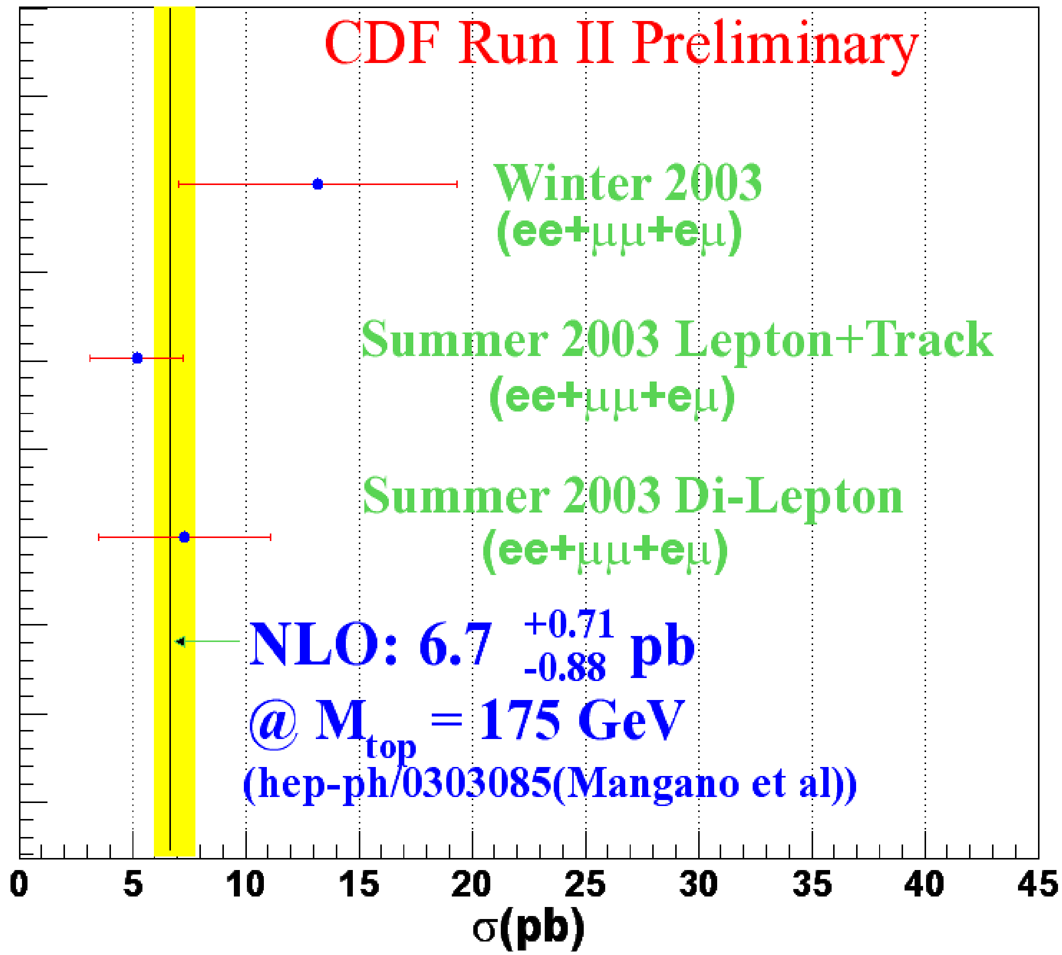
- Winter result: 13.2 ± 5.9(stat) ± 1.5(syst)
- Theoretical prediction @ 175 GeV, E_{CM} =1.96 GeV:

  σ_{tt} = (6.7+-0.5) pb (hep-ph/0303085)

Dilepton Cross Section Run II



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B-tagging Information

- Expected tags:
  - Tag rate per top event: (55 +-1+- 5) %
  - N_{tagged} (expected) = (3.92 ± 0.24) events
  - N_{tagged} (observed) = 6 events

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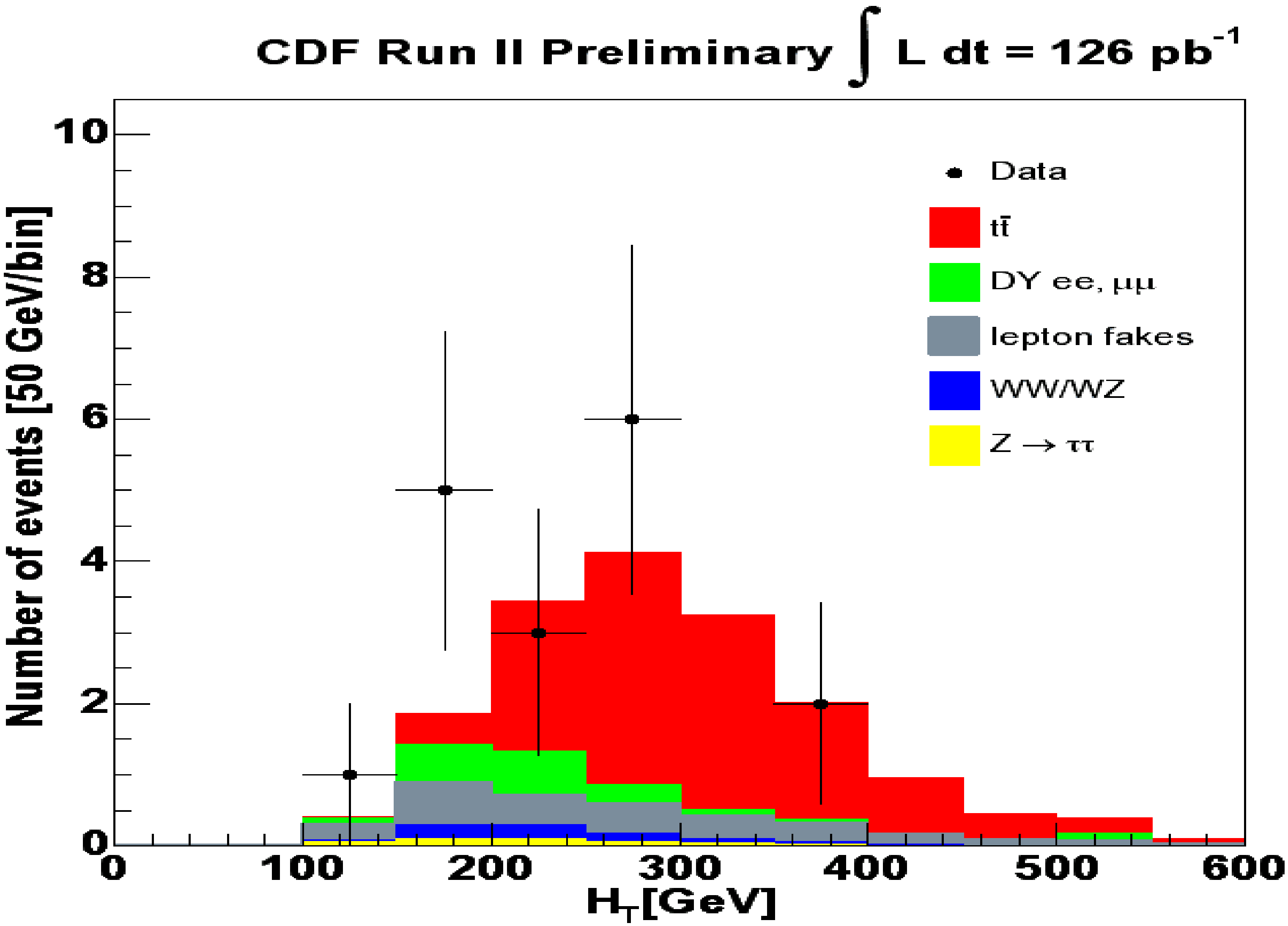
- One double tagged event (CMUP/CMP)

Kinematic Plots I



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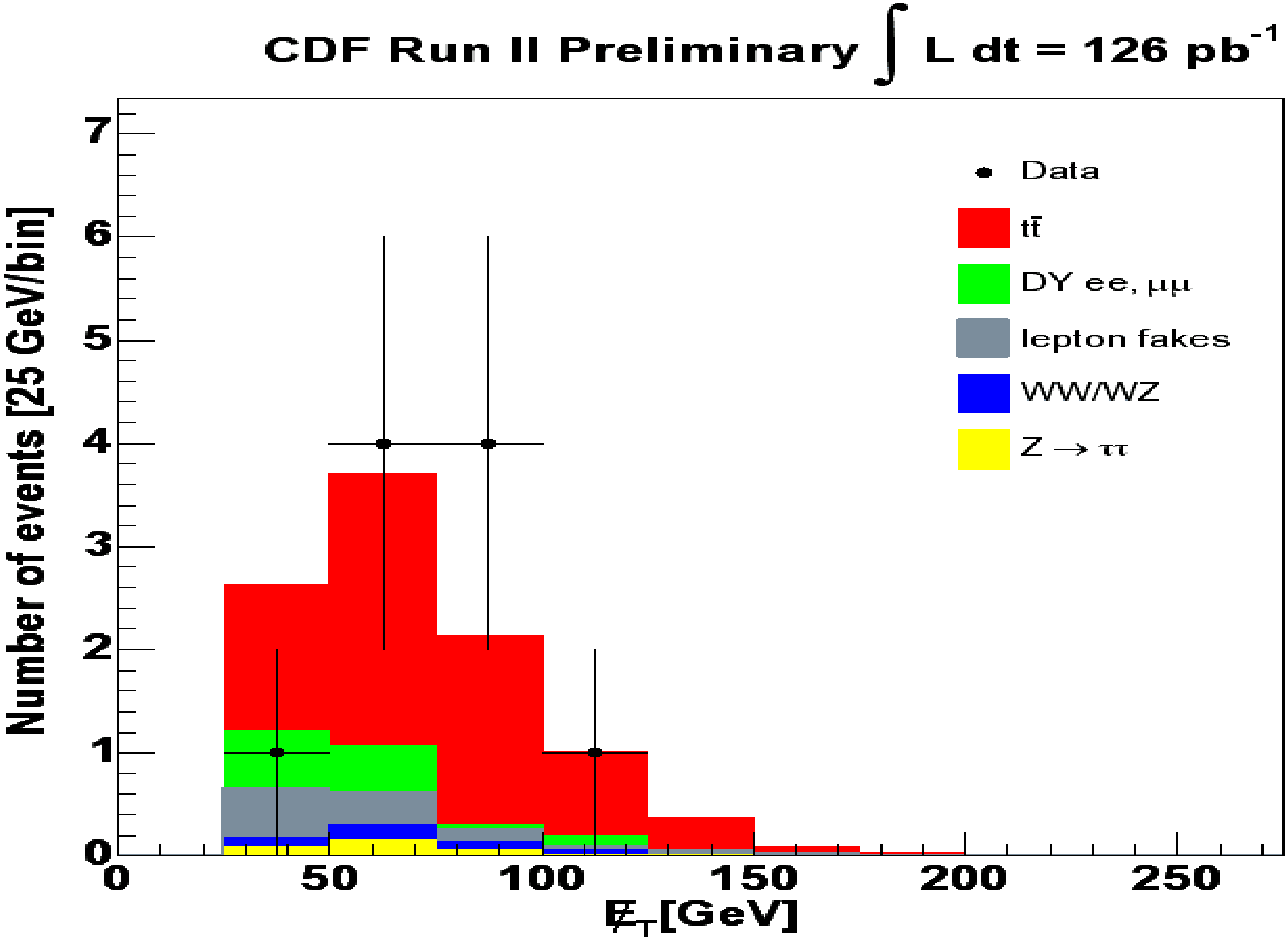
Kinematic Plots II



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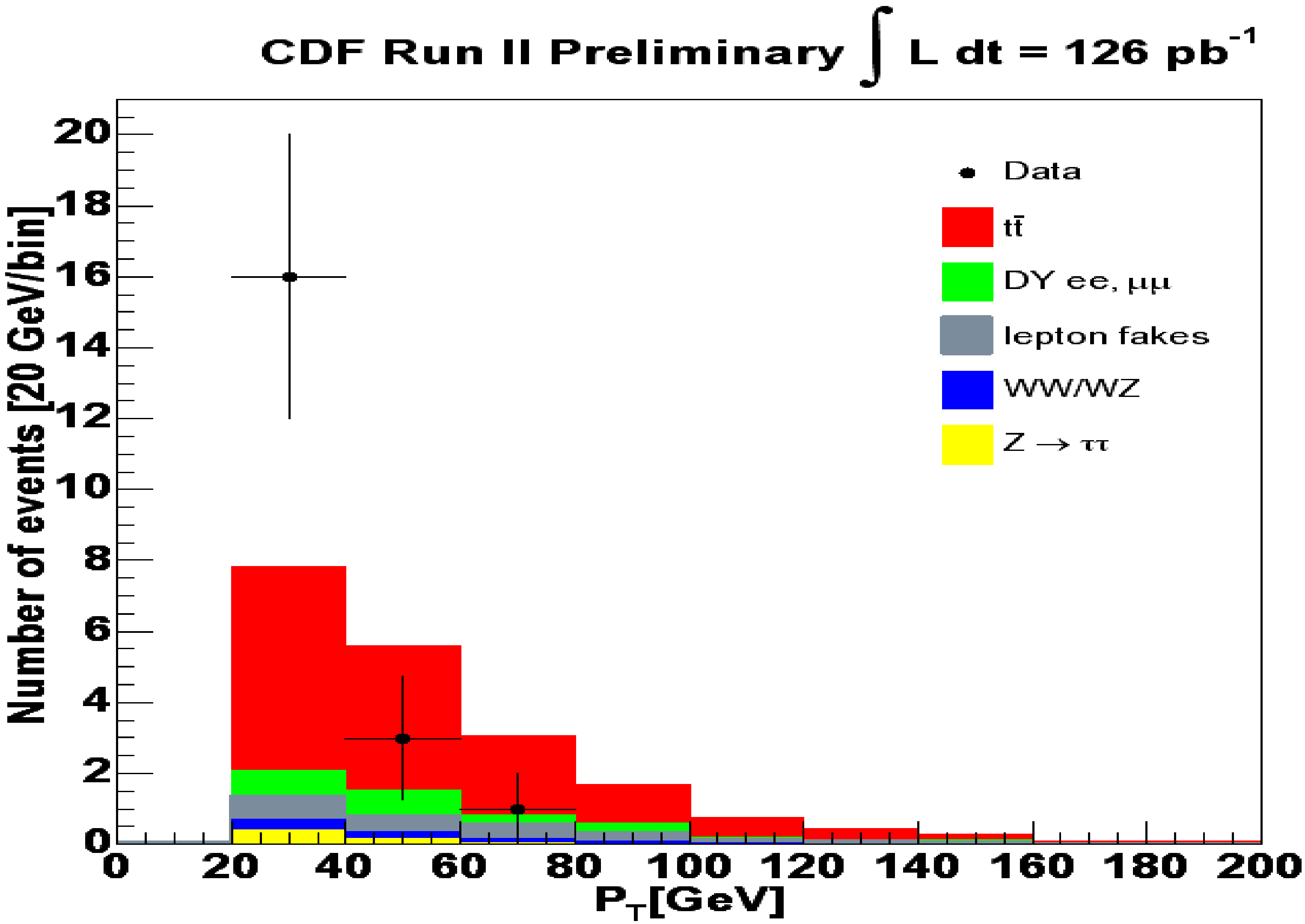
Kinematic Plots III



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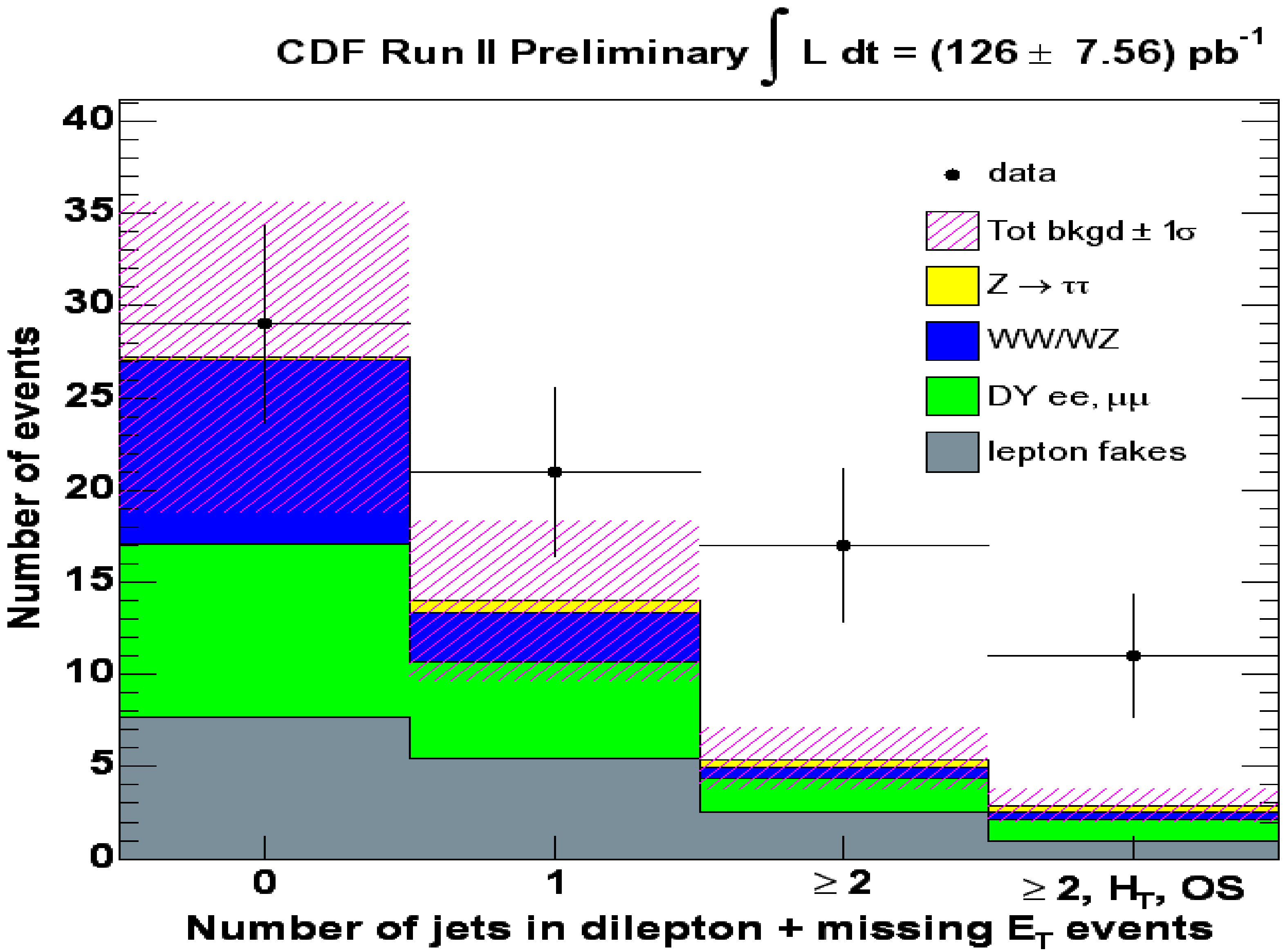
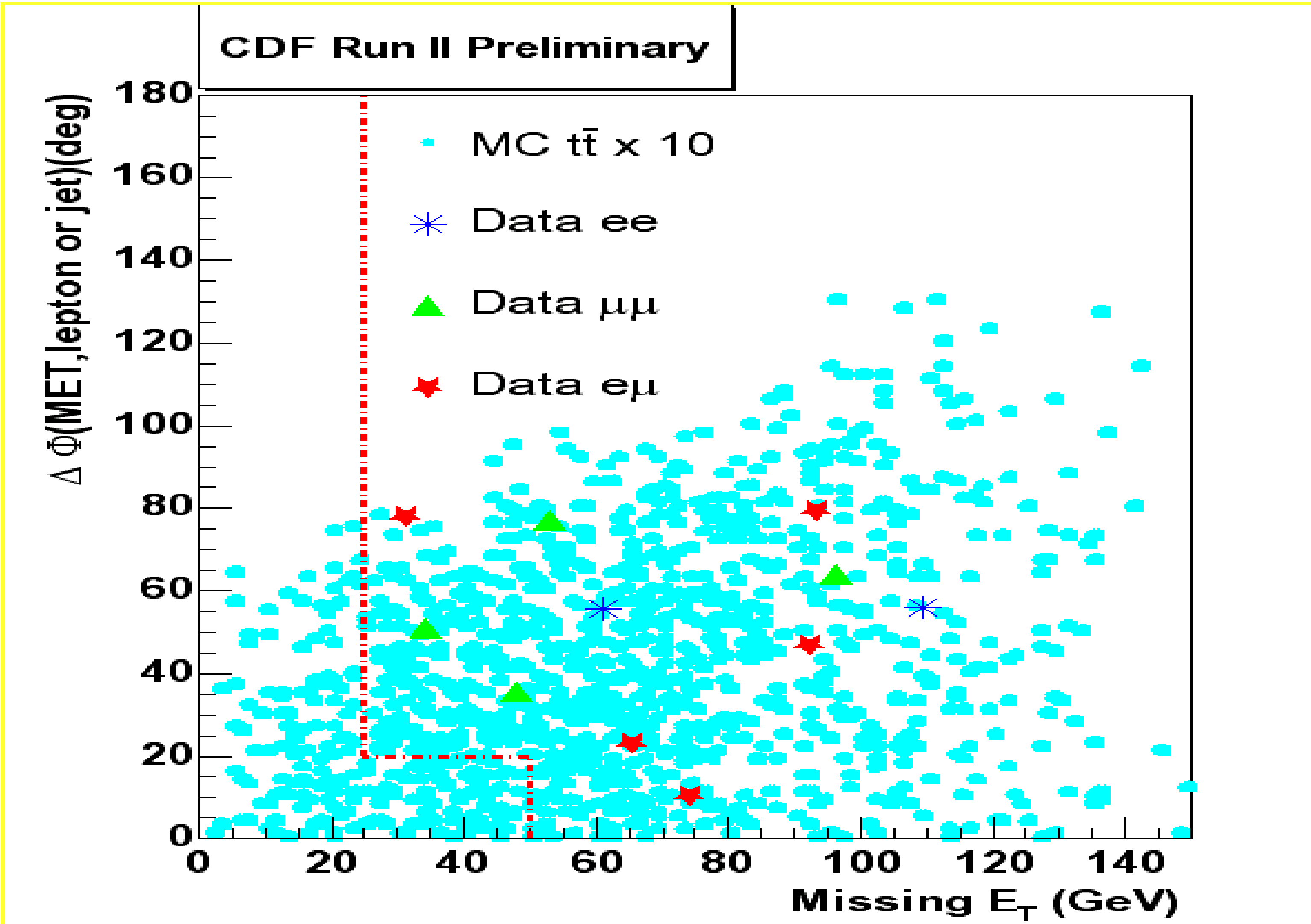


CDF Run II Preliminary ∫ L dt = (126 ± 7.56) pb^-1
Number of events
40
35
30
25
20
15
10
5
0
data
Tot bkgd ± 1σ
Z → ττ
WW/WZ
DY ee, μμ
lepton fakes
0
1
≥ 2
≥ 2, H_T, OS
Number of jets in dilepton + missing E_T events

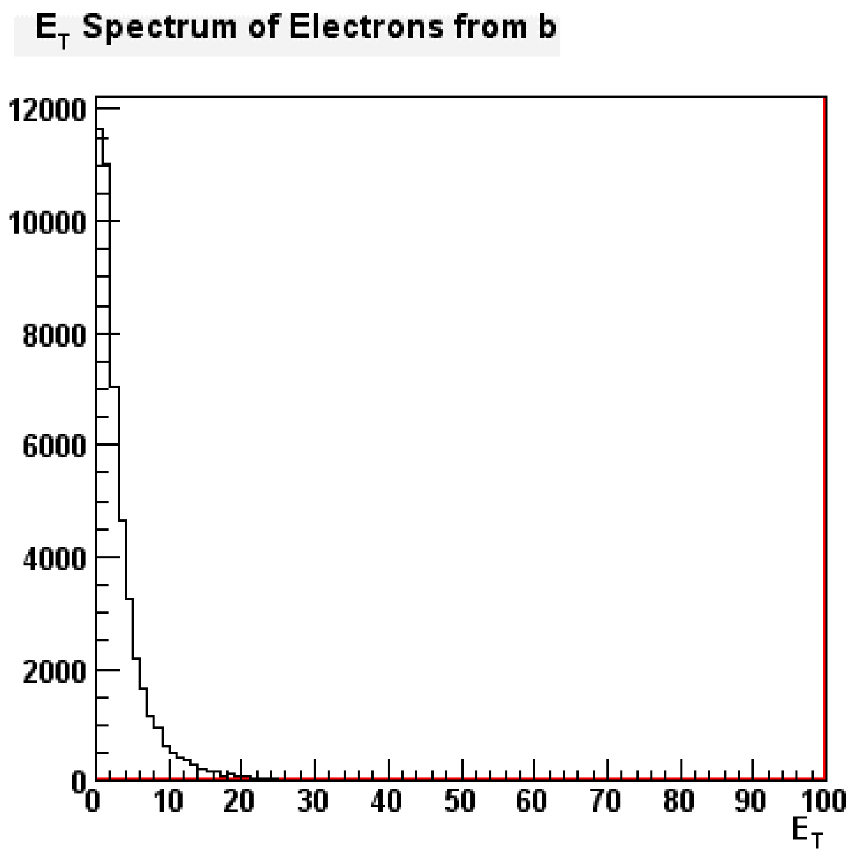

CDF Run II Preliminary
MC $t\bar{t}$ x 10
Data ee
Data μμ
Data eμ
Δ Φ(MET,lepton or jet)(deg)
Missing E_T (GeV)
0
20
40
60
80
100
120
140
160
180

PR Event Displays

Backup Slides

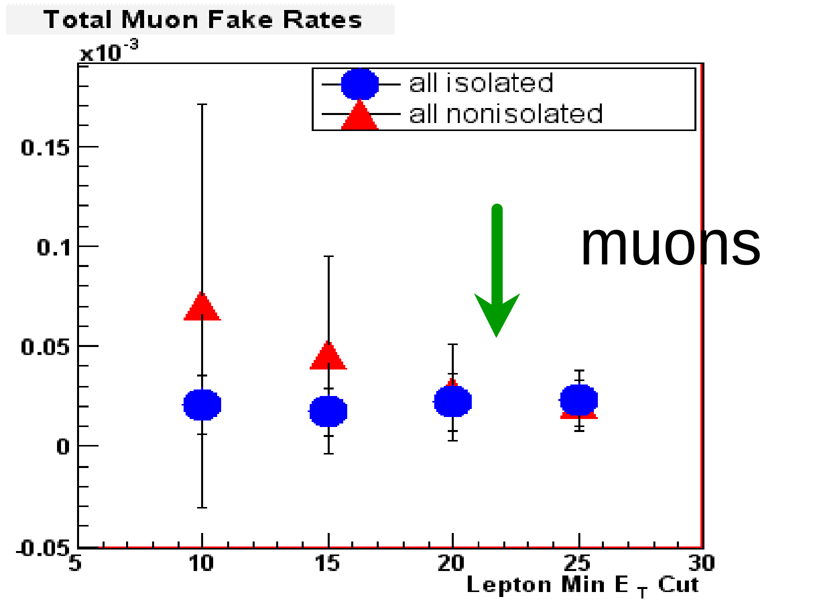
Fakes from b jets (I)

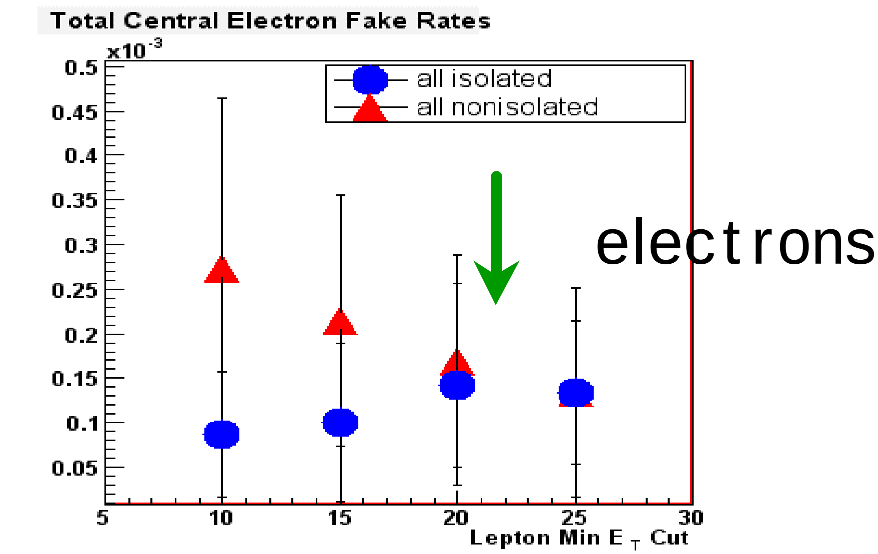
- Believe NI leptons not faked by b's because of E_T cut on electron
  - Not many b's with electrons > 20 GeV
    - Et spectrum of electrons from b's in Wbb plotted at right
    - This plot is just to give a qualitative sense for this contribution
- If this is true, shouldn't we start to see b's if we lower the cut?



Fakes from b jets (II)

- Yes, and we do.
- Non-Isolated fake rates (RED) go up as E_T cut on lepton is lowered,
- At 20 GeV, rates are comparable to isolated lepton fake rates (BLUE).





Fakes from b jets (III)

Measured fake rates using the 8 GeV lepton samples stripped by the b-tag group

- select events with a SECVTX tag
- measure muon fake rate in electron triggered sample and vice-versa to avoid trigger bias

Lepton Type	Fakes	Number of b-jets (+ tracks)	Fake Rate
NICMUP	1	21,347	4.7×10^{-5}
NICMU	0	21,347	$< 4.7 \times 10^{-5}$
NICMP	1	21,347	4.7×10^{-5}
NICMX	0	21,347	$< 4.7 \times 10^{-5}$
NICMX	0	21,347	$< 4.7 \times 10^{-5}$
NICEM	3	20,528	1.5×10^{-4}

To be compared with fake rates from generic jets:

μ: 3×10^{-5}

e: 2×10^{-4}

HF fraction in W+jets to be ~1% ? fake rates for b's would have to increase by a factor of 100 to be comparable to those from light quark jets.

We do not see any evidence that this is the case.

W+heavy flavor MC estimates

- Use the numerous W+HF AlpGen+Herwig samples to estimate background per 100 pb^{-1}.
- In 100 pb^{-1} : < 0.08 events ?? Can these be wrong by x25??

atop16 W(μν)bb0p	0.0022 evts	atop13 W(eν)cc0p	0.0064 evts
atop10 W(eν)bb0p(OLD)	0.0066 evts	atop19 W(μν)cc0p	0.0038 evts
atop40 W(eν)bb0p(NEW)	0.0035 evts	atop0w W(eν)c0p	0.007 evts
atop41 W(eν)bb1p	0.0046 evts	atop3w W(μν)c0p	< 0.012 evts (0 evts pass all cuts)
atop1w W(eν)c1p	0.0043 evts	atop4w W(μν)c1p	0.026 evts

Changes to Event Selection

- Extend jets to $|\eta| < 2.5$
    - Winter analysis used $|\eta| < 2.0$
- Cutting on corrected instead of raw quantities
    - Use Jet Corrections 1,2,3,5
    - Count jets with corrected $E_T > 15$ GeV
        - Winter analysis used raw $E_T > 10$ GeV
    - Use these jets to correct MET and calculate H_T
- As was done in Run I, loose central leptons not required to be isolated
    - Does not apply to CMIOs
- Trilepton category added
- CMX muons no longer vetoed if have CMU/BMU stubs

Acceptance Corrections

- Rescale lepton ID efficiencies to match those observed in Z data; Scale Factors applied:
  - CMUP: 0.94 +/- 0.01
  - CMX: 1.00 +/- 0.01
  - CMU: 0.97 +/- 0.02
  - CMP: 0.96 +/- 0.02
  - TCE: 0.98 +/- 0.01
  - NI TCE: 0.78 +/- 0.07
  - PEM: 0.96 +/- 0.05
  - NI MUONS: 0.85 +/- 0.09
- Apply track efficiencies
- Decreases overall acceptance by 6.6%

New Z Veto

- Not so new:
  - CDF 3387 (H. Frisch)
- Exploit the fact that MET from top is real while MET in Z+jets results from jet under-measurement
  - Expect that higher jet ET $\rightarrow$ higher jet fluctuation $\rightarrow$ larger MET.
- Events with MET > 60 GeV ->jet lost in a crack (η = 0 or 1.1)-> use $\Delta\phi$(MET, jet) to reject those events

$$jetsig = \frac{MET}{\sqrt{\sum_{|\Delta f(met, jet) < 90|} \left(\vec{E}_T jet \cdot \frac{\overrightarrow{MET}}{MET} \right)}}$$

MET/σ_{MET}

Dilepton Categories

- Events are required to have two leptons
  - At least one of which is TIGHT ISOLATED lepton
- Trigger lepton is required to be TIGHT
- Permuting TIGHT with LOOSE
  - **26** dilepton categories
    - ee: 5 categories
    - eμ: 9 categories
    - μμ: 12 categories
  - **1** trilepton category

<u>**TIGHT**</u>	<u>**LOOSE**</u>
CEM	PEM
CMUP	CMU
CMX	CMP
PHX	CMIO

Data candidates

- 10 candidates:
  - ee: 2 events
  - eμ: 5 events
  - μμ: 3 events

1 CEM-CEM
1 CEM-PEM
2 CEM-CMX
1 CEM-CMIO
1 CEM-CMU
1 CMUP-CMP
1 CMUP-CMX
1 CMX-CMX